Transition to literacy

CHAPTER 7

KNOWLEDGE VALORISATION

7.1 RELEVANCE

The ability to read and write effectively serves as an important dimension of human capital in today's modern and knowledge based societies. Reading is a complex cognitive process that involves the mastery of a set of arbitrary printed symbols which enable us to acquire meaning from written linguistic messages. While humans are born to speak, literacy ability is an acquired set of skills that doesn't come natural. Instead, it requires intensive and explicit instruction. It is therefore remarkable that the large majority of children learn to read and write with relative ease. Nevertheless, there is still a substantial part of the population that struggles with the acquisition of reading skills despite adequate reading instruction and sufficient cognitive ability. These people are suffering from developmental dyslexia, a specific learning disability with a neurological basis that is known to run in families (Pennington & Olson, 2008). Most researchers agree that dyslexia has a genetic component and difficulty with fluent reading is the most characteristic symptom that can persist into adulthood (Katzir et al., 2006). While the present thesis sets out to investigate the primary cognitive symptoms and underlying causes of this disorder to possibly aid future diagnostic and intervention efforts, it is important to also acknowledge the secondary consequences with which dyslexic readers struggle. Not being successful in de acquisition of literacy can result in emotional and behavioral problems, such as frustration, low self-esteem and motivational challenges, which, in turn, may have negative effects on social well-being, economical success and educational opportunities. Most professions in Western cultures require adequate literacy skills, and the need for highly educated people is increasing rapidly in an era of fully autonomous cars, 3D printing and artificial intelligence, causing more and more jobs to become obsolete. If we look at the numbers, the human capital that is affected by dyslexia in the Netherlands alone is approximately 640.000 individuals of the general population. Unsurprisingly, dyslexia is considered the most prevailing developmental disorder acknowledged in the Western world. If I could simply answer the question central in this valorisation paragraph, as to how my research may disseminate into value for society, it would be that it adds to the theoretical understanding of dyslexia deficits, and as such, would benefit dyslexic individuals and those that guide them in the future.

7.2 THE VALORISATION CHALLENGE

Nowadays, academic communities are expected to increase knowledge valorisation of its scientific output. Maastricht University challenges its PhD students to explore the bridge between science and the market or practice, and, to this aim, asks them to elaborate on the possibility to "*creating value from knowledge, by making knowledge suitable and/or available for social (and/or economic) use and making knowledge suitable for translation into competitive products, services, processes and new commercial activities*" (Maastricht promotion regulations, 2013). To me this seems like a fair challenge and it is logical that the University feels responsible to prepare PhD students for a future in which valorisation is becoming more and more eminent. If we, for example, choose to continue to work in the scientific arena after we obtain our PhD degree, we collectively compete for highly selective research grants that nowadays always ask for a well formulated valorisation strategy. Alternatively, knowing how to valorise one's obtained knowledge and skills outside the ivory tower of academia seems like an enriching exercise, since the reality is that the majority of PhD graduates, like me, will leave the academic sphere and therefore need to think about how to apply and invest their built experience in a new profession. I do feel that this process, of making assumptions about the value of your research, comes with a large responsibility, and has to be done with consideration. If, for example, the claims of the before mentioned valorisation strategies proposed in most grant proposals, which almost always suggest tangible benefits for society, would have come true, consensus on how to define a specific learning disability like dyslexia, or a cure for, for example, Parkinson's disease, would have surely been found by now. Especially in research fields like dyslexia and reading research, which has known great debate since its inception in the second half of the nineteenth century, a feeling of responsibility, when valorising research findings into the practical domain, is ever so important. The dyslexic population is considered very heterogeneous, which resulted in the formulation of numerous theories that try to explain the variable cognitive symptoms observed in dyslexic readers from a variety of research perspectives and backgrounds. Consequently, many myths and misconceptions surround dyslexia research and practice. Generalizing research findings without knowledge of the right context, theoretical framework and background expertise, may result in harmful or inappropriate translation into practice. Factors like, for example, orthographic depth of the language in which children learn to read, age and environmental or genetic influences, need to be taken into account, to avoid that dyslexic children and their caregivers are misguided by wrongly valorised products or methods, promising a cure for the reading challenges haunting them. Think of colour overlays or tinted lenses, special balancing exercise programmes, brain

stimulating methods, modelling clay letters or a prescription of fish-oil tablets, often expensive methods that unrightfully claim their existence in some kind of theoretical findings. Not surprisingly, most of these remedies have been highly contested due to a lack of actual scientific evidence backing up their effectiveness. I am hopeful that, in the future, the practice of valorisation will become a more integrated competence in the training of PhD students in which connections to society and conversations with the market place or practice will play an increasing role.

7.3 FIRST STEPS OF LITERACY ACQUISTION: FINDINGS AND PRACTICAL SUGGESTIONS

Reading research is a field that is very complex due to the interrelations and reciprocal influences between cognitive reading and reading-related processes, like phonological awareness, rapid naming, letter knowledge and letter-speech sound mapping, also studied in this thesis. The design we choose for our first two studies (chapter 2 and 3), being a 3-year longitudinal follow-up and starting prior to the commencement of formal reading instruction, enabled us to unravel this entanglement and provided an important window on the causal mechanisms involved in the developmental dynamics of reading acquisition. By comparing pre-literate children, with and without an increased familial risk of becoming dyslexic, we could, moreover, shed light on the cognitive dynamics underlying emergent reading failure early on, before children fall behind. This work is relevant for children that struggle with reading acquisition and the educators, parents and other caregivers that guide them, as these findings might, in the future, improve diagnostics processes and the development of early intervention for this group. This is especially true for dyslexia professionals working with children learning to reading in relative transparent orthographies, since most previous work was conducted in English.

We found that prior to reading instruction letter-sound knowledge is a particularly important predictor of early reading in grade 1, in both at-risk and control children, and that RAN at this time plays a predictive role in at-risk reading fluency outcome in grade 2. Phonological awareness (PA) only became the important grade 1 predictor of reading the subsequent year, but only in children without a familial risk, showing normal reading acquisition. Letter-speech sound mapping (LS) remained the core predictor of at-risk reading outcome. Although longitudinal predictor studies cannot decide on causal influences of predictors to reading outcome, it is surprising that PA did not emerge as the main predictor of reading in light of the largely supported claims of the phonological deficit theory of dyslexia, claiming a causal role of PA in reading development. The assumption that a PA deficit precedes and directly influences a

reading deficit, although never proven, has been a truism for many reading researchers over the years. From a practical point of view, such an unsettled claim may be misleading educators and dyslexia professionals, expecting difficulties in the ability to manipulate spoken language prior to the start of reading instruction as a preluding symptom of troubled, subsequent reading. We found no support for this claimed PA-reading relationship. In more detail, only a very small proportion of at-risk children exhibited phonological awareness or other phonological processing problems prior to reading, and only a part of these children developed a reading deficit. Furthermore, 80% of all at-risk children who developed a reading deficit performed in the normal range on all of our kindergarten PA tasks. On the contrary, a PA deficit only emerged after the start of reading instruction in grade 1 and in close relation with a developing reading deficit. More specific, at-risk and control children with reading problems did develop a PA deficit in grade 1. Our results thus render against the causal claim of the phonological deficit theory.

Our findings are clear within a scientific scope and reflect the state of the art for now. The findings have limits, as always in science. First of all, the sample is not fully representative given the diversity within dyslexia and a definition of representative samples is not available yet. Second, the study related to a Dutch sample and cannot be generalized to other languages directly. Having these limits in mind we should advise with caution. Hence with caution, we advise the following in an attempt to aid parents, educators and dyslexia professionals guiding reading disabled children in their first steps of literacy: (1) Firstly, know your family history and be aware of the fact that your child may have an increased chance of struggling with reading acquisition if you or one of your child's siblings is dyslexic. Keep in mind that such an increased risk does not necessarily akin to a definite reading deficit, since approximately 50% of at-risk children will develop reading skills within the normal range (present thesis, Pennington & Olson, 2008). Similarly, not having a recognizable family risk does not guarantee your child will not need special guidance with reading, since around 5% of no-risk children will also struggle with reading acquisition (Blomert, 2005). (2) If a child shows inadequate PA ability once reading started in grade 1, this is a tell-tale sign of a reading deficit developing in close relation. Prior to reading however, a causal link is less likely. If you, for example, encounter a child with a PA deficit prior to the start of reading instruction, this does not necessarily indicate they will struggle with reading acquisition later on, and vice versa, not finding a PA deficit does not indicate that a child will develop adequate reading skills. Practically speaking, this indicates that there is no need for concern by parents or educators, if a pre-reading child is not able to accomplish the PA exercises, which are already part of the (preparatory) reading methods offered in Dutch kindergartens. (3) Be aware of a child's ability to correctly match

letter-speech sound pairs, since difficulties shown as early as kindergarten, can be a sign of later reading failure in children at familial risk. We also found that difficulty in learning these cross-modal orthographic-phonological pairs via a specifically design training can be a characteristic of a core group of kindergarten at-risk children. These training-resistant at-risk children may benefit from early special attention or adapted instruction. (4) Regular follow-up is recommended since cognitive signs of dyslexia become relevant at different developmental stages or reading levels in at-risk and no-risk children. Starting at a young age with a variety of tests will, in the future, increasing the change of identifying these children early and enables dyslexia professionals to develop adapted, intensive guidance for struggling readers, and to minimize any accompanying secondary social or emotional consequences as quickly as possible.

7.4 CLUSTERING INSIGHTS AND FUTURE DIRECTIONS

The evident degree of heterogeneity observed in the total reading disabled population has puzzled reading researchers for decades. Traditionally, classification studies that attempted to confirm the existence of more homogeneous subtypes within this diverse group did so based on a predefined division, determined by cut-off criteria and existing theoretical insights regarding aetiology and subtypes. The design we choose for our third study (chapter 4), being a bottom-up, data-driven classification in a large sample of grade 2 to 4 poor readers, enabled us to zoom in on this divers phenomenon and revisit the possibility of identifying distinct cognitive deficit profiles, without making any a priori assumptions on the nature and number of possible subtypes. As such, we looked beyond an adopted theoretical framework and its possible limitations.

Our findings confirmed the possibility to find more homogeneous subtypes of reading disability and identified four cognitive profiles: (1) a Reading-only impaired subtype without underlying cognitive deficits, (2) a General poor subtype with deficit across all general and reading-related vulnerability markers, (3) a PA-LS specific poor reader type characterized by a PA deficit and impaired letter-speech sound mapping skills and (4) a PA-RAN specific poor reader type characterized by a PA deficit and impaired rapid automatized naming ability. The Reading-only impaired profile showed a less severe reading deficit compared to the other profiles and moreover was the only type that showed normal spelling skills. Profiles 1, 2, and 3 were more characterized by environmental risk factors, while the fourth profile (PA-RAN) showed a significantly strong familial risk for dyslexia. These later PA-RAN

specific poor readers showed significantly higher IQ scores than the other two profiles that showed distinct underlying deficit pattern. Interestingly, these emerging cognitive profiles based on behavioral measures were in line with earlier finding of genetic and neuroimaging studies, showing the existence of two potential aetiologies for childhood reading failure; a predominantly genetic, specifically impaired reading type with IQ scorers over 100 and a more environmental influences type with IQ scores below 100 (Shaywitz & Shaywitz, 2005; Wadsworth et al., 2010). It is relevant for educators and dyslexia professionals to know that it is possible to identify poor reader profiles characterized either by family risk or by environmental risk factors solely based on behavioral measures. Reading and reading-related deficits that are due to a substantial larger genetic influence for example require more intensive remediation efforts (Wadsworth et al., 2010). It is important to remember however that family risk it is not a purely genetic trait, since children share both genes and home literacy environment with their close relatives. Also of practical value is the insight that, although IQ has fallen out of favour for sole diagnosis of dyslexia based on discrepancy or cut-off criteria (e.g., Stuebing et al., 2002), the way it forms distinct patterns with reading-related vulnerably markers and family risk may render valuable information for exclusion purposed in diagnostic processes (e.g., Wadsworth et al., 2010). A one-size-fits all approach may not be adequate for the overall reading disabled population. Instead, a more fine-grained approach focusing on different profiles may be a more promising way forward in tailoring future diagnostic and intervention efforts more precisely to the needs of a specific cognitive profile. It would be interesting to further research whether the identified cognitive profiles of poor reading also respond to training differently and how these cognitive profiles develop over time.

Once the practical implications of these subtypes are further investigated, we could think of valorising these cognitive profiles further by using them alongside a newly to be developed diagnostic tool that can effectively be used in a diagnostic setting or classroom. Such a tool would use a child's test scores on the nine included cognitive behavioural vulnerability factors (PA accuracy, LS identification and discrimination accuracy and fluency, RAN, memory, IQ and vocabulary) to make a diagnostic allocation of an individual being tested for dyslexia into one of these four identified subtypes. For the development of such a tool a number of techniques can be borrowed from the data science and machine intelligence domains, for example a technique called k-NN (k-nearest neighbour, e.g., Aha, 1991). This instance-based learning method classifies individual test scores according to their proximity or belongingness to members of the existing model (in our case the four identified subtypes that resulted from a K-means data driven classification). More in detail, the k-nearest instances (i.e., neighbours (children) with similar cognitive profiles) can be easily retrieved and, through a majority voting schema, the class with the

highest number of nearest neighbours is chosen. A method like K-NN is powerful, since it does not assume anything about the data being clustered, and it moreover offers confidence (percentage) of belongingness (to a class or subtype). In other words, educators and dyslexia professionals using such a diagnostic tool may gain insight on classification accuracy of that individuals cognitive profile, which for example corresponds to 70% subtype 1, 15% subtype 2 and 15% subtype 3. We would recommend utilizing periodic revaluation to determine whether the obtained latent clustering and level of belongingness continues to be appropriate. More precise clustering is not only beneficial from a practical diagnostic or remediation perspective, future research in genetics and neuroimaging may use such a pre-processing instrument for sample classification. If, for example, research would zoom in on children with a high belongingness to the PA-RAN subtype, which unveiled a significantly high familial risk of dyslexia, it is possible that genetic techniques may achieve a different result than that when focusing on the reading disabled sample as a whole. Finally, the result of this thesis may also be of interest to policy makers with respect to healthcare and treatment costs offered to children with dyslexia. The Dutch political and societal framework of healthcare and insurance of dyslexia changed in 2009, when the national Healthcare Insurance Board (College voor Zorgverzekeringen, CVZ) adopted the protocol Dyslexia Diagnostics and Treatment (Blomert, 2006). In more detail, this protocol guides dyslexia professionals along five steps that can lead to a positive or negative indication for subsequent dyslexia-diagnostics and treatment. Children with a positive indication are eligible for reimbursement of the costs of dyslexia care, which was implemented step-wise; starting in 2009 with children that obtained their indication before the age of nine, until in 2013, care was reimbursed for all children in primary school from ages seven to thirteen years old. The cognitive measures our subtyping classification was based upon, is part of the Dyslexia Differential Diagnosis 3DM battery (Blomert & Vaessen, 2009), the test battery that was developed in service of the five steps introduced in the before mentioned protocol. Adding a more fine-grained approach by employing mathematically strong data driven techniques, may add much needed nuance to policies that decide on who is eligible for care and financial compensation. Moreover, an eloquent tool such as the one described above seems a possible, innovative addition to the 3DM test battery.

REFERENCES

Aha, D. W., Kibler, D., & Albert, M. K. Instance-based learning algorithms (1991). *Machine learning, 6* (1), 37-66. doi : 10.1007/BF00153759.

Blomert, L. (2005). Dyslexie in Nederland - theorie, praktijk en beleid [Dyslexia in The Netherlands - theory, practice and policy]. Amsterdam: Nieuwezijds Publishers.

Blomert L. Protocol Dyslexie Diagnostiek en behandeling [Protocol dyslexia diagnostics and treatment] Maastricht: University of Maastricht; 2006.

Blomert, L., & Vaessen, A. (2009). *3DM: Cognitieve analyse van lezen en spellen [3DM: Cognitive analysis of reading and spelling].* Amsterdam: Boom test publishers BV.

Katzir, T., Youngsuk, K., Wolf, M., O'Brien, B., Kennedy, B., Lovett, M., & Morris, R. (2006). Reading fluency: the whole is more than the parts. Annals of Dyslexia, 56, 51-82. doi:10.1007/s11881-006-0003-5.

Pennington, B. F., & Olson, R. K. (2008). Genetics of Dyslexia. The Science of Reading: A Handbook, 453-472. doi:10.1002/9780470757642.ch24.

Shaywitz, S. E., & Shaywitz, B. A. (2005). Dyslexia (Specific Reading Disability). *Biological Psychiatry, 57*(11), 1301-1309. doi: 10.1016/j.biopsych.2005.01.043.

Stuebing, K. K., Fletcher, J. M., LeDoux, J. M., Lyon, G. R., Shaywitz, S. E., & Shaywitz, B. A. (2002). Validity of IQ-Discrepancy Classifications of Reading Disabilities: A Meta-Analysis. American Educational Research Journal, 39(2), 469-518. doi:10.3102/00028312039002469.

Wadsworth, S. J., Olson, R. K., & DeFries, J. C. (2010). Differential genetic etiology of reading difficulties as a function of IQ: an update. Behavior Genetics, 40(6), 751-758. doi: 10.1007/s10519-010-9349-x.